Automated Orbital Mapping

Statistical Data Mining of Orbital Imagery to
Analyze Terrain, Summarize its Characteristics and
Draft Geologic Maps

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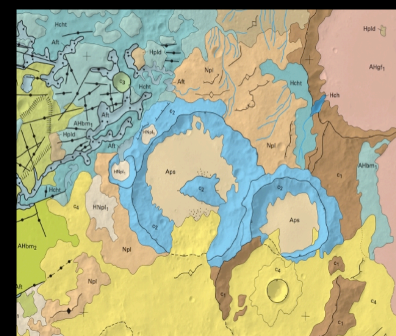
Motivation

- Geologic mapping requires skill, consistency, and stamina



- USGS has finished maps covering < 10% of Mars
- USGS Mars geologic maps in progress are based on Viking orbiter imagery

Objectives

- Utilize hyperspectral image features
- Infer maps from unlabeled data
- Create statistical data products
- Improve feature detection accuracy

Outcomes

- Increased speed of orbital image analysis
- Improved consistency of mapping
- Expanded complexity of geologic analysis

Impacts

- Immediate preliminary maps
- Comprehensive mapping
- Continuous map and model refinement

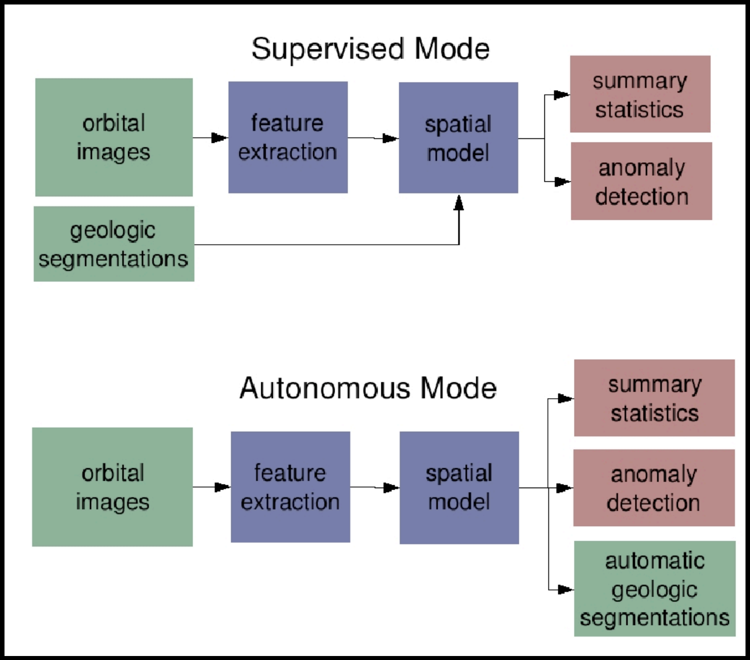
Approach

- Categorize data sources and analyze for (hyperspectral) feature properties
- Develop feature detectors
- Spatially register and segment data
- Learn association to geologic type
- Apply to current and future observations

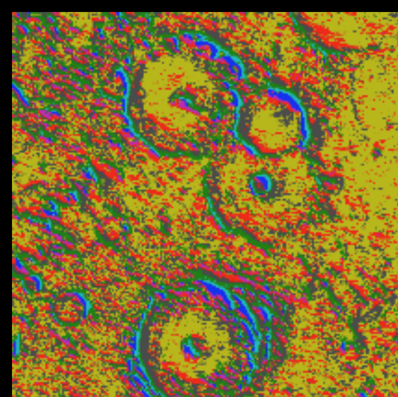
Approach

Train in supervised mode using geologists region identification

Apply in autonomous mode to process existing and future data



Method

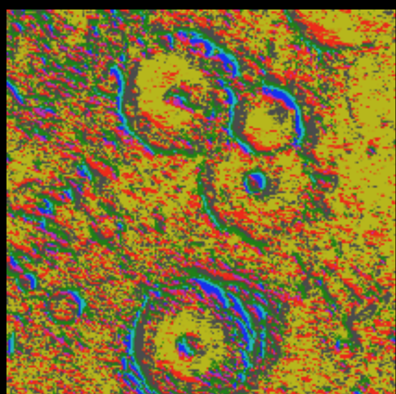


Pixel-level attributes

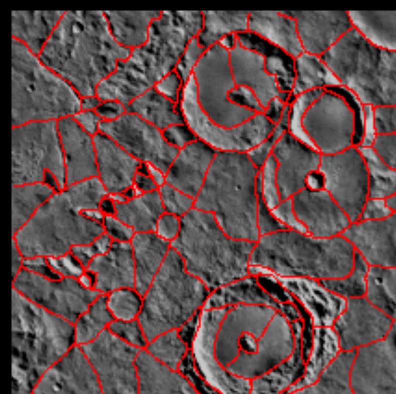
Pixel Attribute Extraction

Texture, multispectral features, edges and contours, elevation model

Method



Pixel-level attributes



Superpixel Segmentation

Superpixel Segmentation

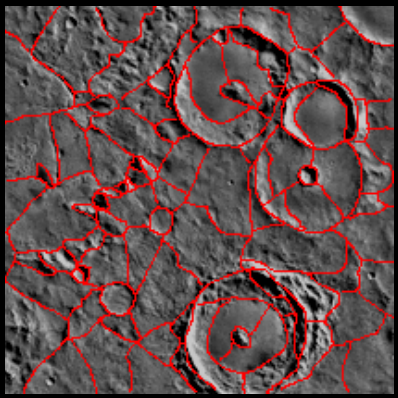
Model features in high-dimensional graphs

Normalized cuts for group similarity and total dissimilarity

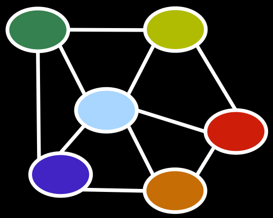
Also examing K-means clustering

Method

Superpixel Attribute Extraction



Superpixel Segmentation

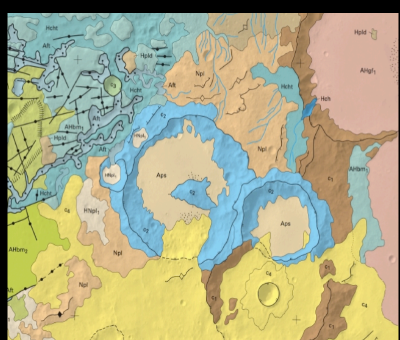


Superpixel Attributes

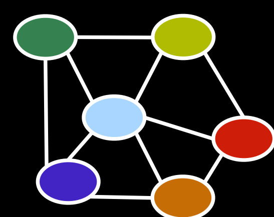
Extract spatially registered textures, edges, morphology, shading, etc.

Form feature vector

Method



Prior Geologic Map



Region Attributes

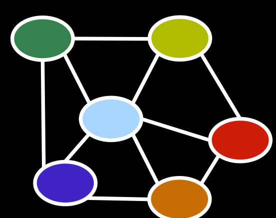
Superpixel Attribute Training

Train using geologist labeled regions & maps

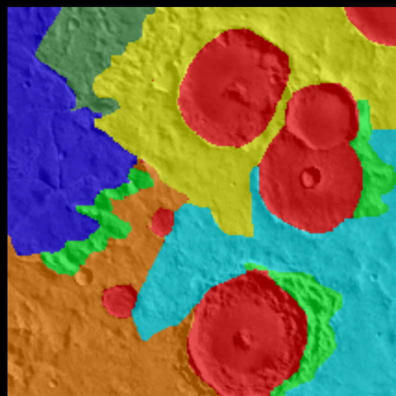
Associate with extracted regions

Method

Spatial Inference, Region Merging, Classification



Region Attributes



Merged Superpixels & Region Labels

Develop conditional random field and search with region label score

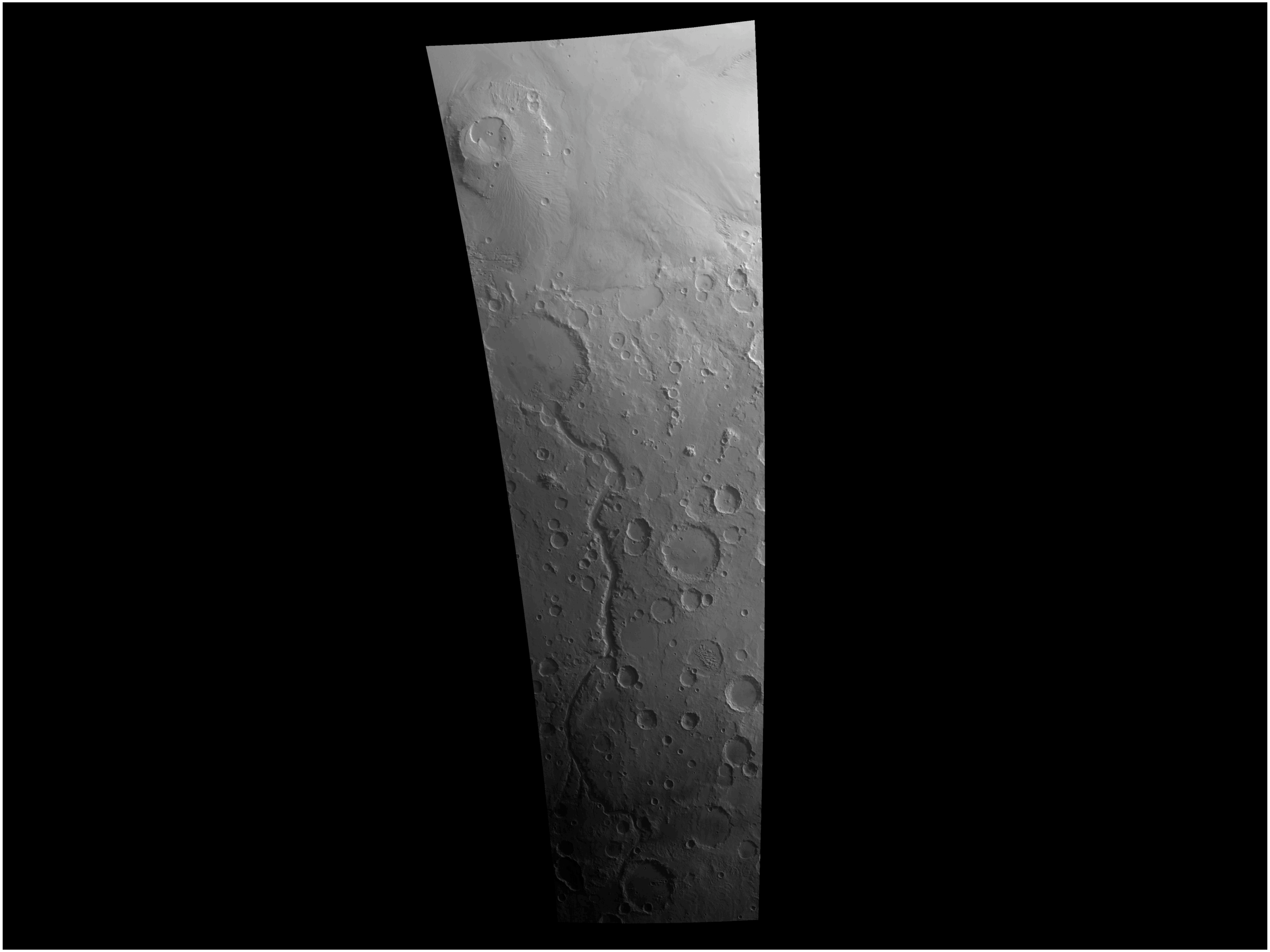
Data Sources

Mars Imagers, Spectrometers and Altimeters

Evaluating instruments and available data

Developing features detectors for as many

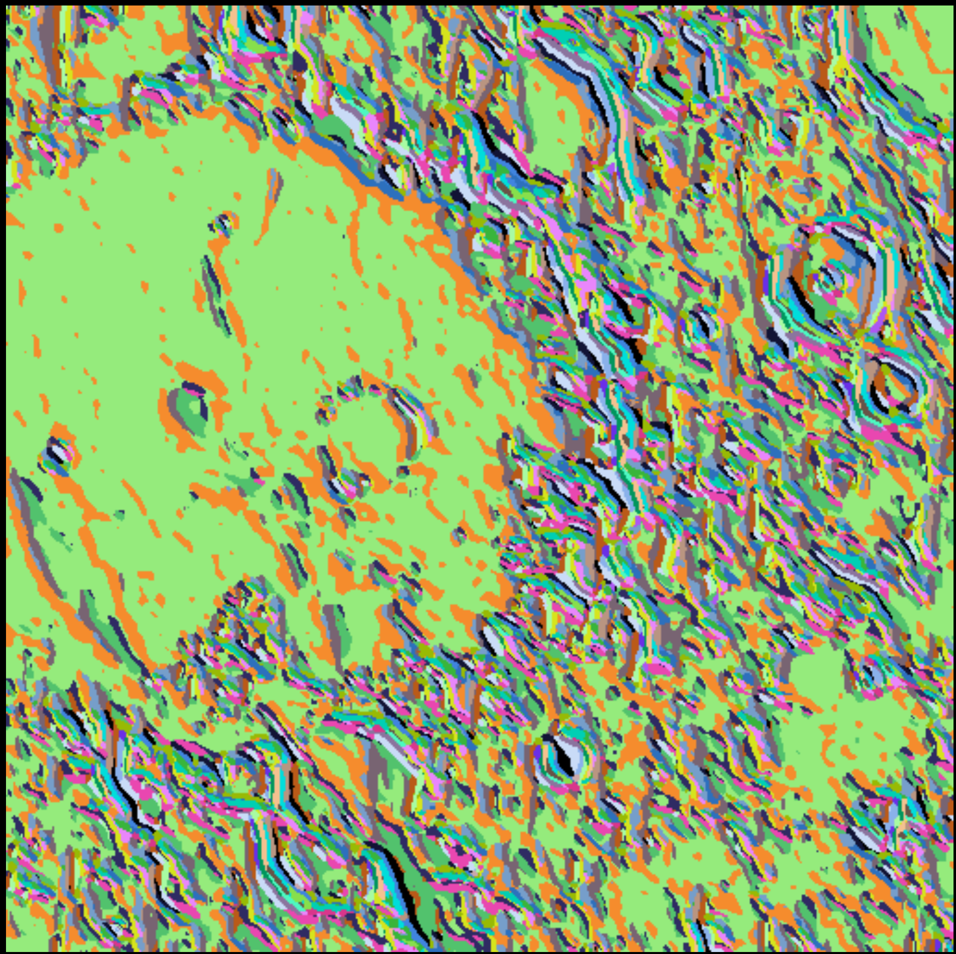
Spacecraft	Instrument	Type	Wavelength	m/pixel
MRO				
	HiRISE	High Resolution Imager	800-1000 nm	0.3
			550-850 nm	
			400-600 nm	
	CTX	Wide Field Imager	500-800 nm	6
	CRISM	Spectrometer	360-3900 nm	19.7
Mars Odyssey				
	THEMIS	Infrared Spectrometer	400-449 nm	18
			515-566 nm	18
			628-686 nm	18
			749-723 nm	18
			837-882 nm	18
			6.27-7.28 um	100
			7.38-8.47 um	100
			7.98-9.14 um	100
			8.75-9.95 um	100
			9.66-10.76 um	100
			10.45-11.64 um	100
			11.26-12.33 um	100
			12.17-12.98 um	100
			14.45-15.32 um	100
	GRS	Gamma Ray	Gamma Ray	300000
			Neutron	
Mars Express				
	HRSC		585-765 nm	10
			395-485 nm	10
			485-575 nm	10
			730-770 nm	10
			925-1015 nm	10
	SRC		585-765 nm	2.3
	OMEGA		0.38-1.05 um	350
			0.93-2.73 um	350
			2.55-5.1 um	350
MGS				
	TES	Spectrometer	6-50 um	3000
			5.5-100 um	3000
			0.3-2.7 um	3000
	MOC	Imager	500-900 nm	1.4
			400-450 nm	7500
			575-625 nm	7500
	MOLA	Laser Altimeter	N/A	475



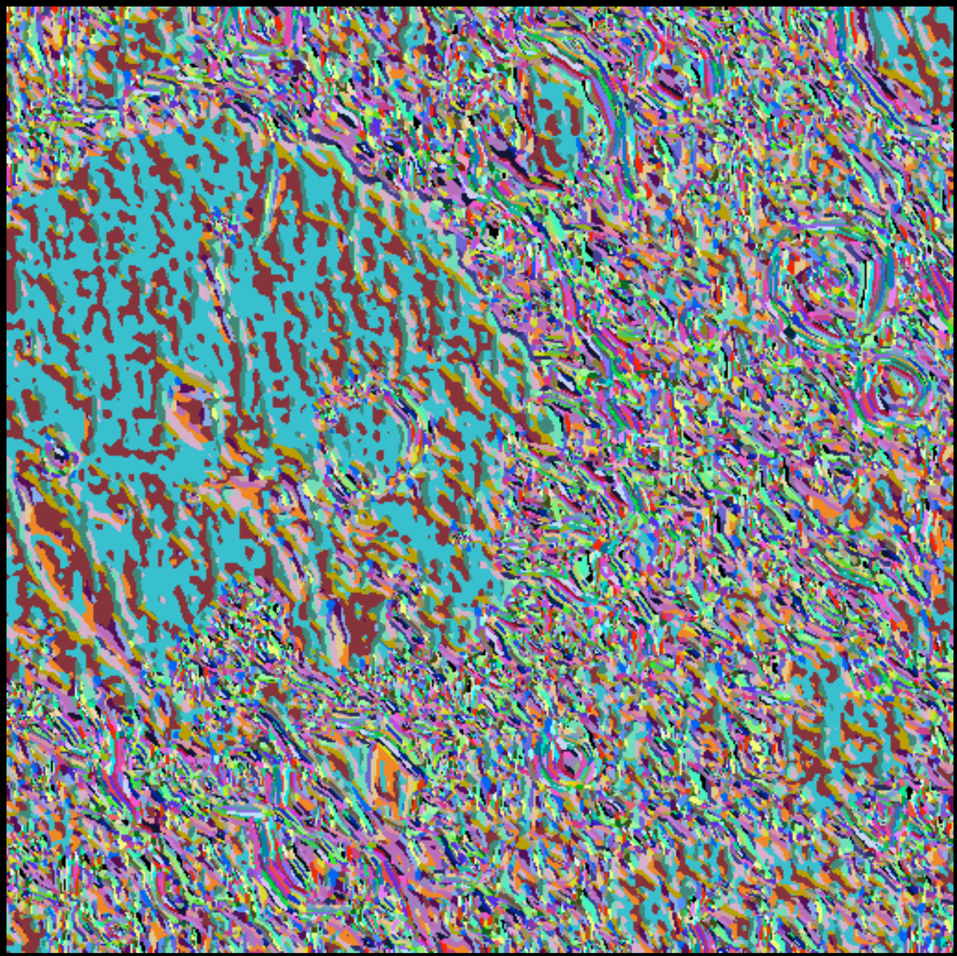
Source Image (HSRC 585-765 nm band)

Creating Textons

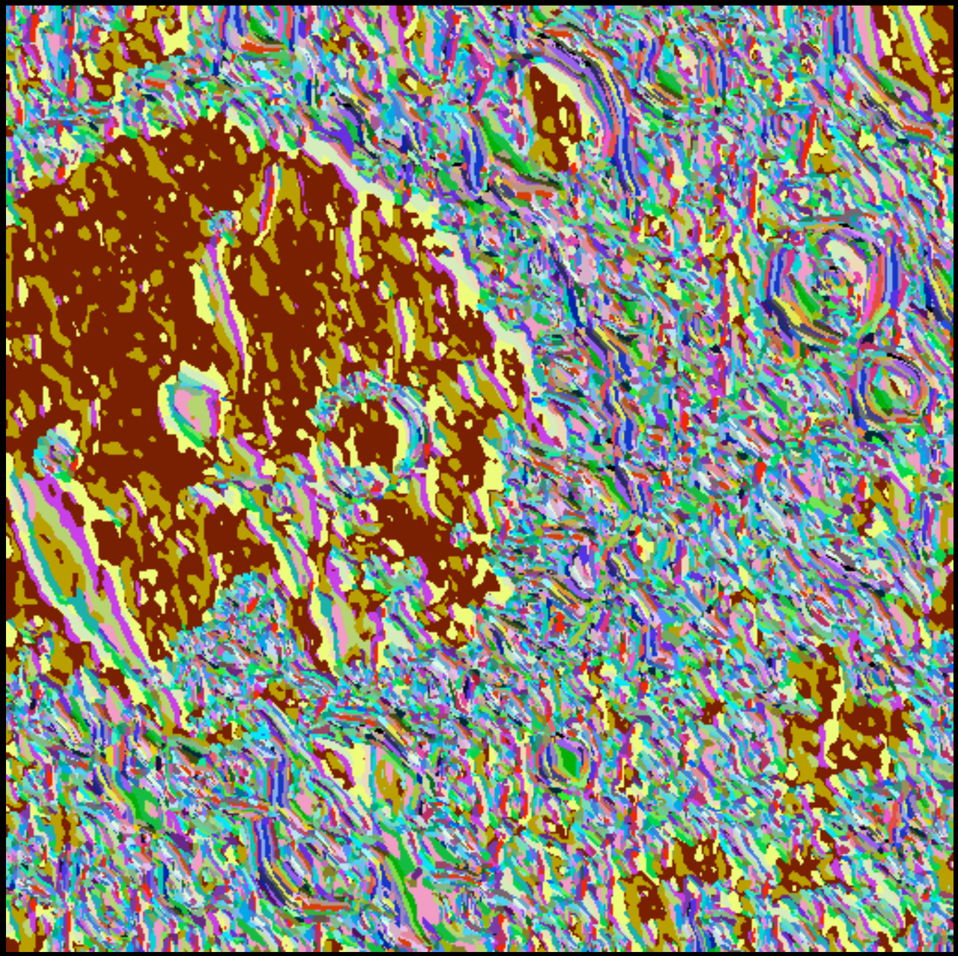
- Convolve steerable filter bank, 16 oriented edge and center surround filters (1/100 image size)
- K-means cluster the filter bank response (16D feature vector for each pixel)
- Cluster centroids define textons



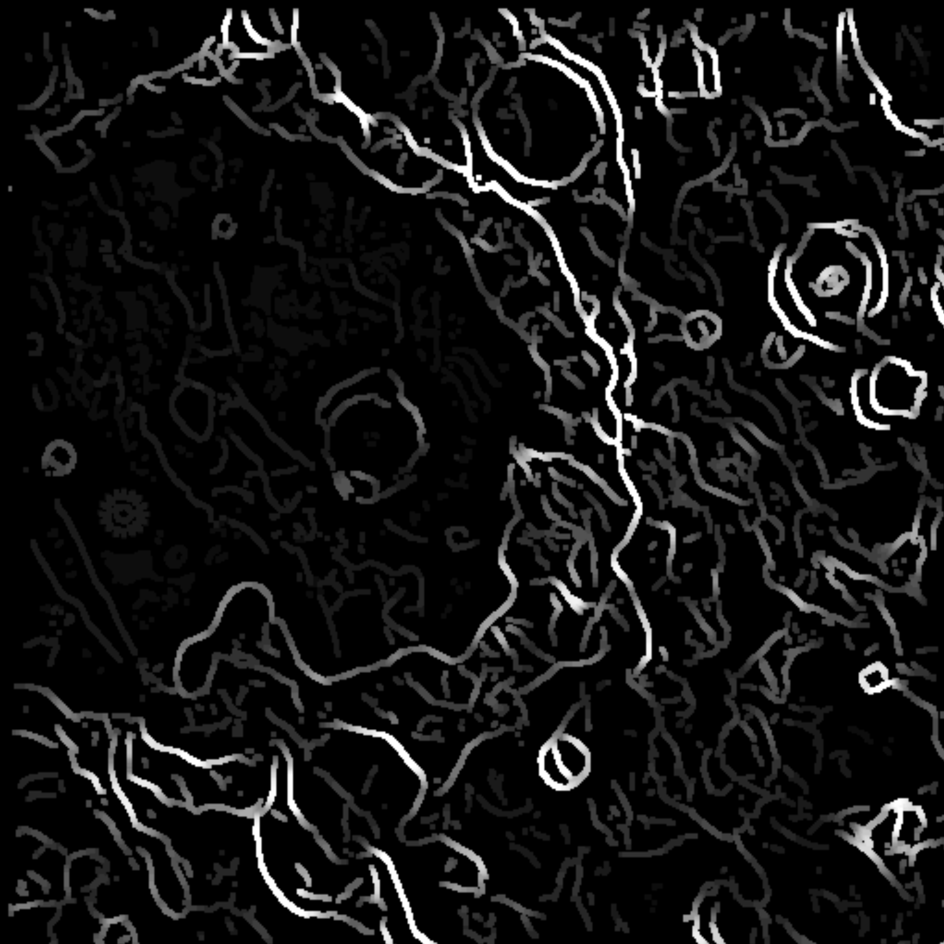
Texton Classification



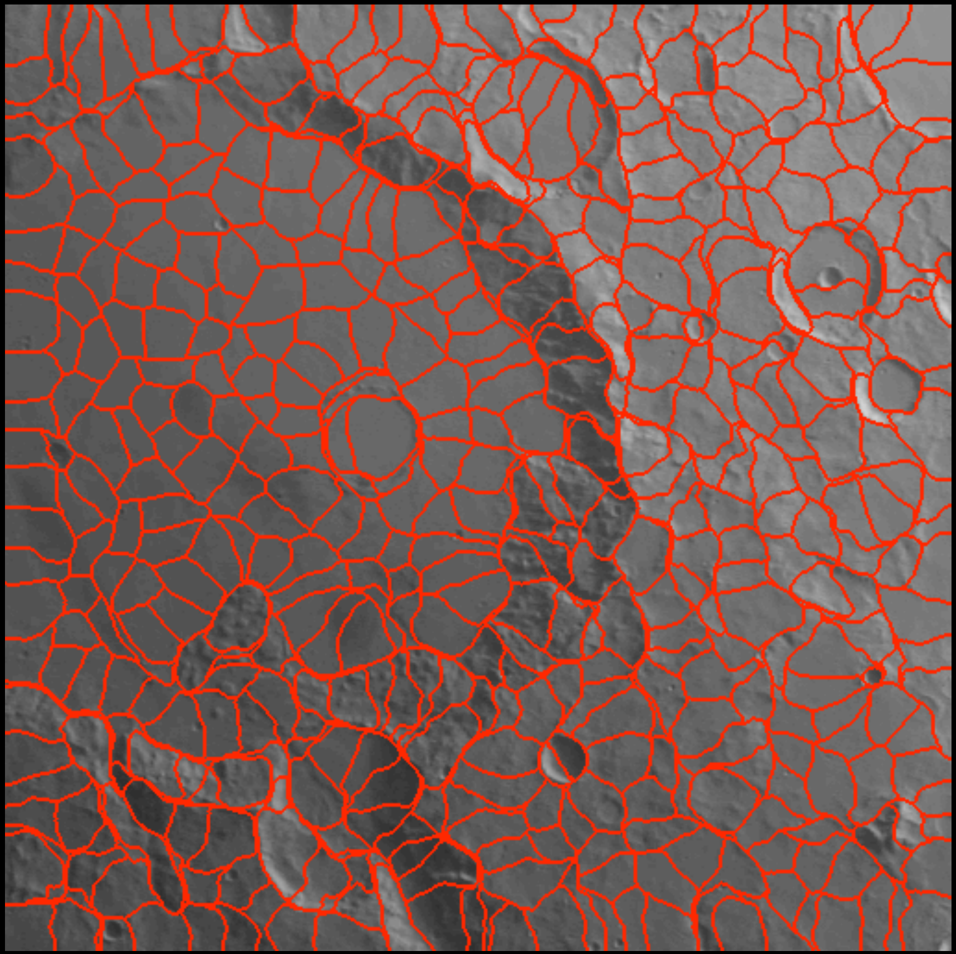
Texton Classification



Texton Classification



Boundary Probabilities



Superpixel Segmentation

Automatic Geologic Mapping

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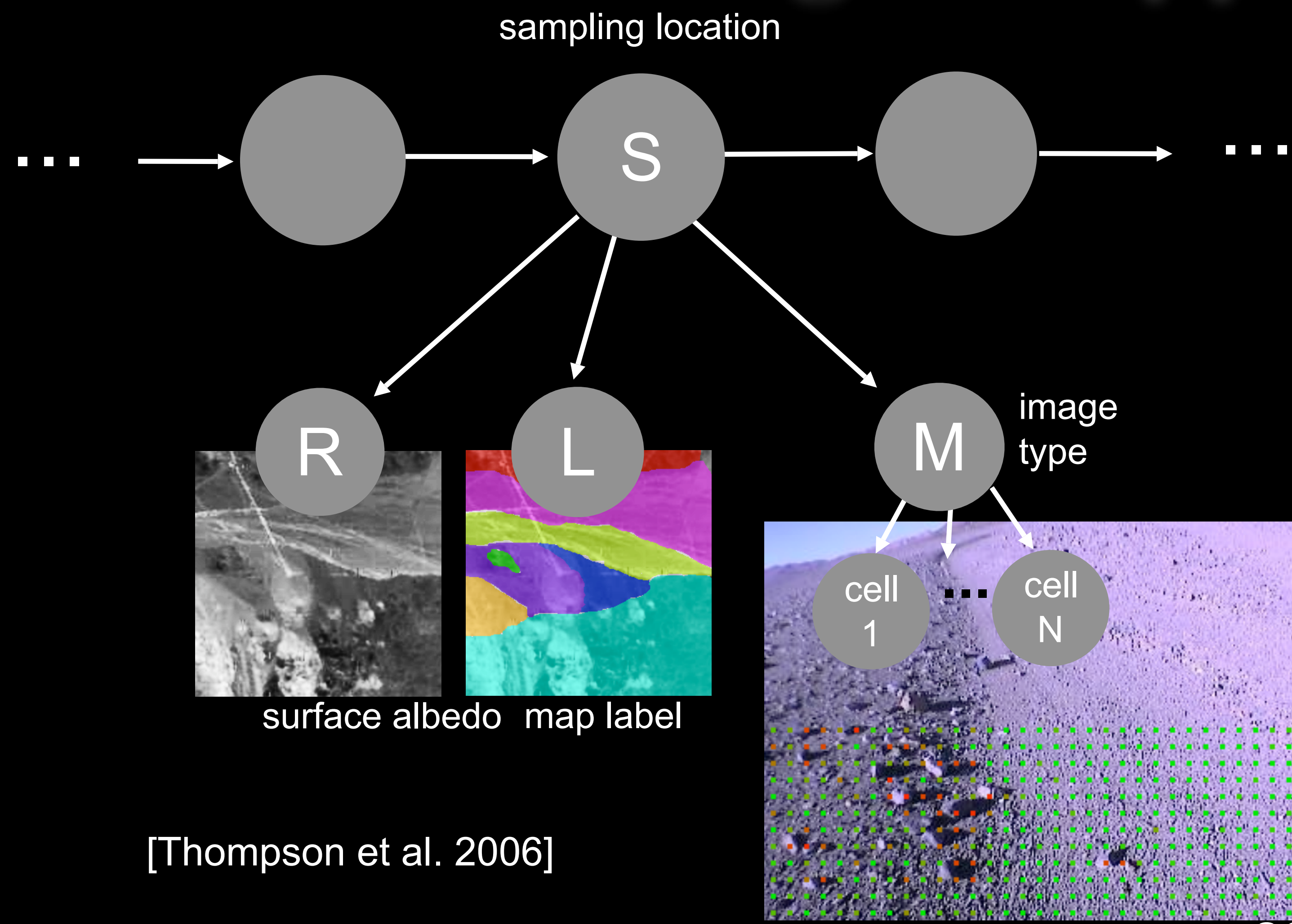
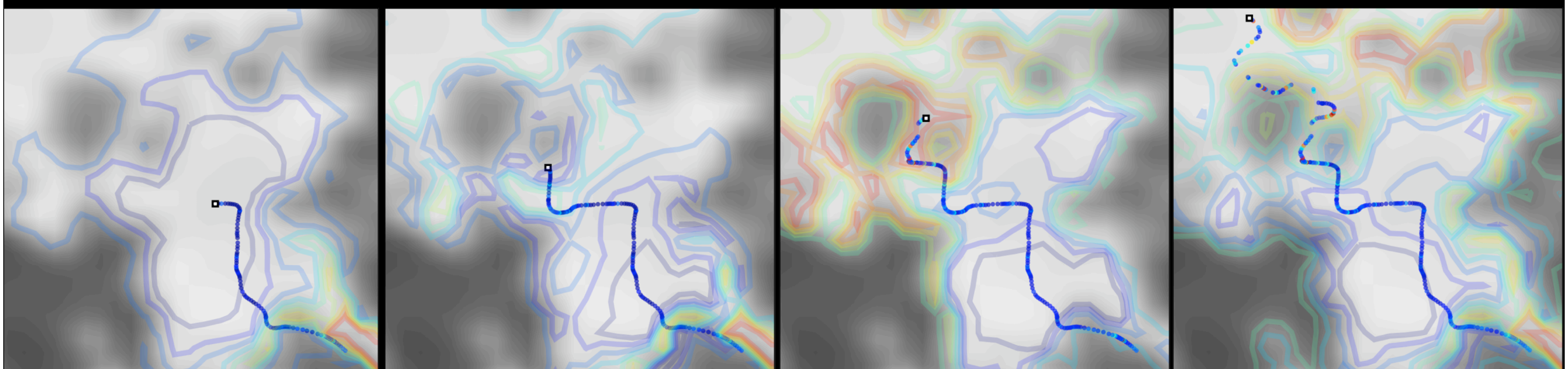


[Thompson et al. 2006]

Automatic Geologic Maps

Surfaced based automatic geologic mapping evolving with new data



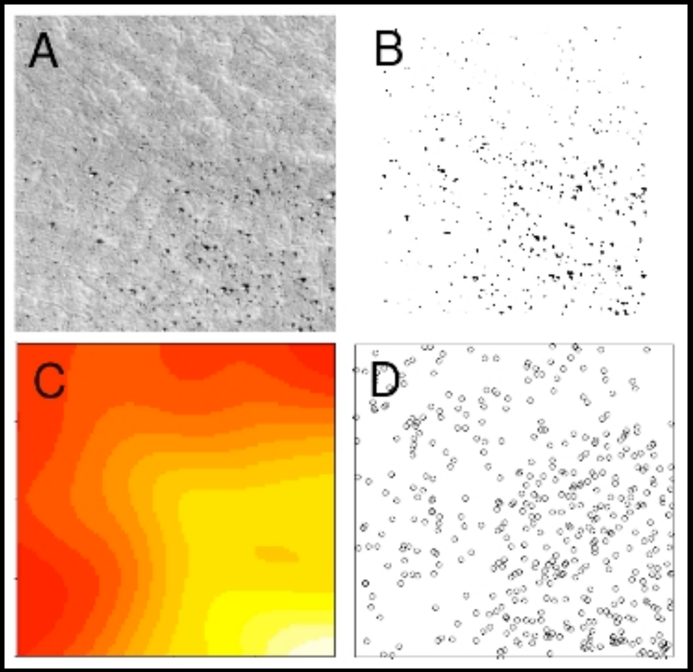
Data Products

Original HiRISE image (A)

Extracted shadow features (B)

Boulder field density (C)

Point process model (D)



Status

- Identified data sources, collecting samples, choosing training sites
- Evaluating feature single-band detectors
- Developing hyperspectral detectors
- Refining automatic classification
- Formulating derived data products

Upcoming

- Create training instances
- Implement automatic classification pipeline for region grouping and labeling
- Evaluate initial mapping results

Questions and Advice?